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ABSTRACT

The proliferation of interest in collaborative computer applications in the past decade has resulted in a corresponding increase in the interest in multi-user interfaces. The current research seeks to contribute to an understanding of the design of multi-user interfaces for a group ranking task, and to the process of design. User requirements were identified by observing groups perform the ranking task in a non-computer environment. A design was proposed based on the identified requirements and a prototype implemented. Feedback from informal user evaluation of the implemented interface is reported. Insights on the methodology are discussed.

Keywords

Multi-user Interface, Group Ranking

INTRODUCTION

The need for flexibility and customizability in group applications has been extensively advocated (e.g., Cockburn and Greenberg, 1993; Smith and Rodden, 1993). In group support systems (GSS), single-user interfaces refer to systems in which each user controls the cursor on his / her screen only. This provides limited flexibility. Multi-user interfaces refer to systems with shared surfaces and multiple cursors, each cursor being under the control of one user. In such systems, users can manipulate a shared set of objects. The changes to the objects are reflected on each user's screen. The ability to choose between single-user and multi-user interface is one of the several customizable features that can be considered. The multi-user interface permits dynamic interactions among group members during the ranking process, as opposed to aggregations of individual rankings when single-user interfaces are used. The current study was undertaken with two complementary goals in mind. First, a prototype of a multi-user interface for group ranking was to be constructed based on observations of users performing the task in a non-computer environment, followed by user evaluation and feedback. User evaluation included an informal comparison of the multi-user interface with a single-user interface. The second goal was to learn about the process of developing multi-user interfaces for GSS in general.

USER-CENTERED DESIGN

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The user-centered design process involves understanding the users' model of a task and building the application to be consistent with the model. For multi-user interfaces, Luk (1994) points out that 'the design of the multi-user interface must take into consideration not only the user cognitive model, as in the design of single user interfaces, but also the patterns of interaction among users' (p. 13). User-centered design begins with an implementation of the system based on an initial user model, followed by an iterative process of testing and enhancing the implementation, until a final design is arrived at (e.g., Sobiesiak, Jones and Lewis, 2002). The preliminary implementation can be based on either designer intuition or other means such as observations of users performing the tasks in a non-computer environment, or some combination thereof. Several researchers (e.g., Vick and Auernheimer, 2003) argue that designer intuition often does not match that of the users. Observing users in a non-computer environment is one of several starting points possible in user-centered analysis and design (Olson and Olson 1991; Baecker et al., 1993; Lu and Mantei 1991). Thus, it can be argued that observations should be used as a starting point, or be used to confirm or supplement designer intuition.

The process of converting observations to an initial design is articulated by Lu and Mantei (1991), and Baecker et al. (1993). Initially, taxonomy of activities is generated (Lu and Mantei, 1991). The activities are mapped to user requirements, which then form a basis for design. Baecker et al followed a similar process except they generated four taxonomies to begin with: taxonomies for roles, activities, document control and writing strategies. The differences along each of these dimensions are considered when specifying user requirements and suggesting design options. Similar methods have been proposed by Sobiesiak et al. (2003).

The mapping of one or more user requirements to a design feature may be hampered by one of two problems. First, it is constrained by existing technologies (Rodden and Blair, 1991). Second, the process of mapping is still an intuitive process. User-centered designers compensate for the shortcomings of using intuition by adopting iterative strategies (Gould et al., 1985; Baecker et al., 1993; Olson and Olson, 1990). The scope of the current study is limited to the observation of users performing the ranking task in a non-computer environment to provide the basis for an initial or prototype implementation, followed by qualitative evaluation of the prototype.

PRELIMINARY ANALYSIS AND DESIGN FOR GROUP RANKING

In this section, the analysis and design process and the prototypical implementation of the design are described. First, a description of the observation process is provided. Second, design features are developed based on an analysis of the observations. The scope of the design process as used in this study is also discussed. Finally, the section describes the prototype interface implemented.

Observation Procedure

Eleven groups of three to six persons were videotaped while performing a group ranking task in a non-computer environment. The items to be ranked were printed on small cards. All groups were asked as a group to rank a list of twenty-five occupations, taken from a study on social status of occupations in order of importance to society. The participants were instructed to keep the cards within the working area on the table, to take as much time as they needed to complete the task, and to interact verbally when necessary during the session. The stack of cards, in random order, was placed in the middle of the working area on the table, and each member of the group had physical access to the complete working area.

Analysis And Design

The videotapes were analyzed using procedures similar to those used by Lu and Mantei (1991). First, a list of activities in the group ranking process was identified. Second, the activities were then clustered under factors to facilitate cogent discussion of related activities. Third, user requirements for the task were deduced from the activities. Last, recommendations of design solutions were derived based on the user requirements.

Groups generally followed similar sequences of steps when performing the task (see Fig. 1). The cards were placed in one stack by the researcher at the beginning. The groups first spread the cards so that they could see all the items. Then, they divided the set of cards into different subsets. Lastly, they ranked each subset of cards and merged the subsets to one set as the final group result.

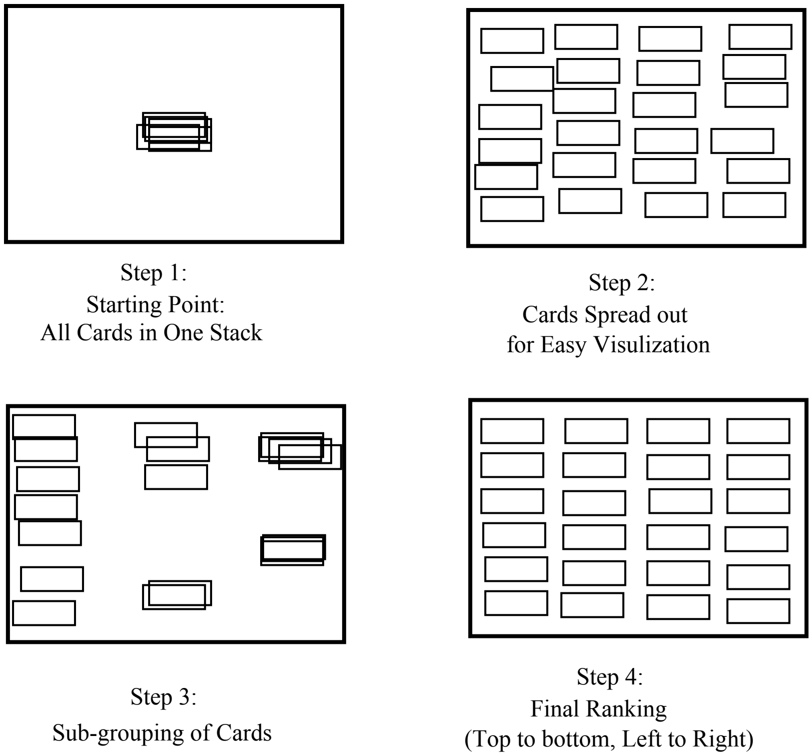


Figure 1. Sequence of Ranking Process Common to All Groups

Fourteen activities were identified, which were then divided into four categories. Categories were identified based on issues discussed in literature and researcher intuition. The requirements identified and the design solutions proposed are discussed below for each category (see Fig. 2a through 2d).

Screen estate management: Interface design must accommodate the fact that screen space is limited. In the non-computer environment, the working space on the table was correspondingly limited. The observations indicate that the activities that affect screen estate management include: *spreading out items*, *agreeing on categorization of items*, *modifying suggested categorizations*, *postponing decision*, *deciding not to rank*, *stacking items*, and *consolidating the subgroups into one final list*.

Based on the observations, three requirements can be identified that would be beneficial to the users. First, the icons denoting the cards should be able to move freely on the working surface, i.e., screen. This will allow the cards to be spread out. Second, it must be possible to let the cards overlap. When cards are allowed to overlap, it will be possible to stack them up, if necessary. Third, there is a further need to indicate the existence of sub-categories of cards. This can be done either by creating formal boundaries or by implying boundaries by putting cards in each sub-category in clusters in different parts of the working space.

The proposed design features include a working space in which the icons representing the cards (henceforth referred to as items) can move freely, overlap if necessary and be stacked. This feature meets the requirement of needing to spread the items and allowing them to overlap. The design does not include formal boundaries for the different categories that are created during the ranking process. The visual segmentation necessary between the different sub-categories is achieved by clustering items in user-defined areas of the screen.

Matrix mode: This factor deals with the activities that help define the design of the grid for ranking the items. The factor could be considered a subset of the screen estate management factor, but we have separated it because ranking is the primary task in the study. The activities include: *agreeing on the rank of a card*, *individuals ranking the items in a subgroup*, *modifying the rank of the card*, and *aligning items*. The following requirements were deduced from the observations. First, it was noticed that all groups ranked in columns and used multiple columns, when one column was not adequate to accommodate all the cards. Second, the insertion of a card between two adjacently ranked cards leads to the requirement that all subsequent cards have to be moved to accommodate the new card, but without disturbing the existing sequence of the cards. Third it was observed, that the participants often adjusted the position of several cards at the same time by using two or more fingers in one smooth motion. From the design perspective, the free working space is convenient for moving the items without restrictions and allowing items to overlap but is not convenient for the requirement of having ranked items adjust automatically when new items are inserted between existing adjacent items. The automatic adjustment requires a grid to be defined, which can anchor the location of the card. The free working space and the defined grid are mutually exclusive modes. A toggle-switch is necessary to switch between the two modes. It was considered appropriate to align the items in columns with no overlapping when the screen was in the grid-mode. If the number of items exceeded the space available on the screen, the excess items will not be visible. As scrolling is an option in the computer-environment, the design allowed the screen to be scrolled to see the excess items. The requirement to move multiple cards independently in one motion is not feasible in a mouse-based system.

Auxiliary working space: The auxiliary working space factor concerns activities that play a supporting role in the group ranking task. The activities include: *individual group members ranking items in a subgroup*, *the recall and clarification of task objective*, and *the recording of ideas*.

The following requirements were identified from the observations. First, individual group members ranked subgroups of items in separate areas of the working space, indicating a need a private space for the activity. Such ranking of subgroups of items can be done in one portion of the main window or in a separate window. Second, participants would occasionally verbalize the goals and other ideas, which was being carried in their heads. The verbalization presumably serves to recall the information for use in the process of ranking, and to test and verify that other members were also using the same criteria and working towards the same goal.

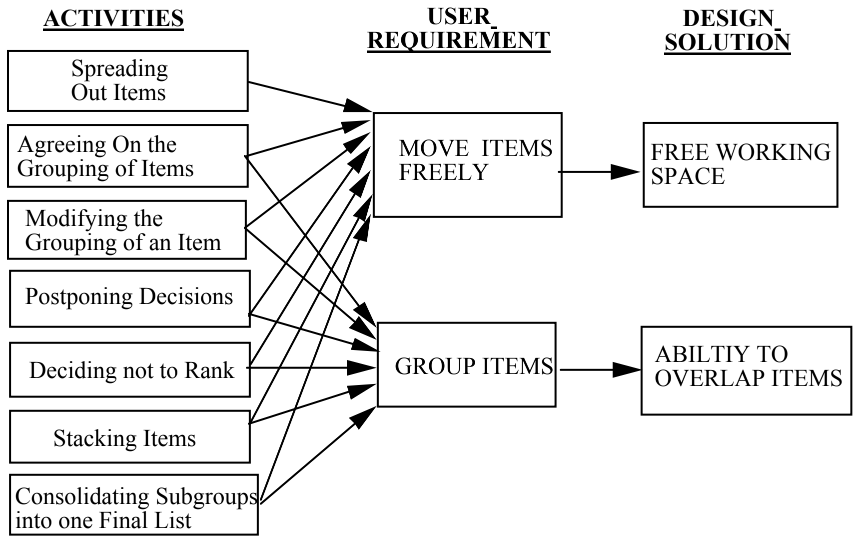
The process of recall can be supported in the design by (a) having an information panel that contained the topic and objective of the task, and (b) by providing a private window for maintaining ideas.

Concurrency control and coordination: This factor pertains to the coordination of group member activities and control of the cards during the ranking process, and how conflicts for control are resolved. It includes the activities of *item control* and *item identification.*

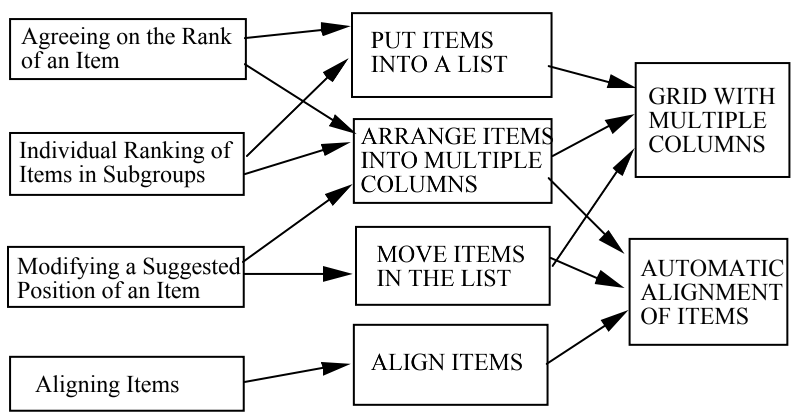
The following requirements were identified. First, participants identify items by pointing to cards without touching the cards while discussing the item. Second, multiple participants pointed to the same card at the same time during the discussions. Third, only one participant has control of a card when moving it.

Design features to accommodate these requirements include multiple cursors, one for each participant. Pointing or identifying an item during discussion can be accomplished by moving the cursor close to the item of interest. A user can obtain control of the item by pointing to the item and holding on the mouse button down. Control is surrendered when the user releases the mouse button.

The mapping of the taxonomy of activities to the user requirements and the mapping of the user requirements to the design solutions are summarized in figures 2a and 2b.

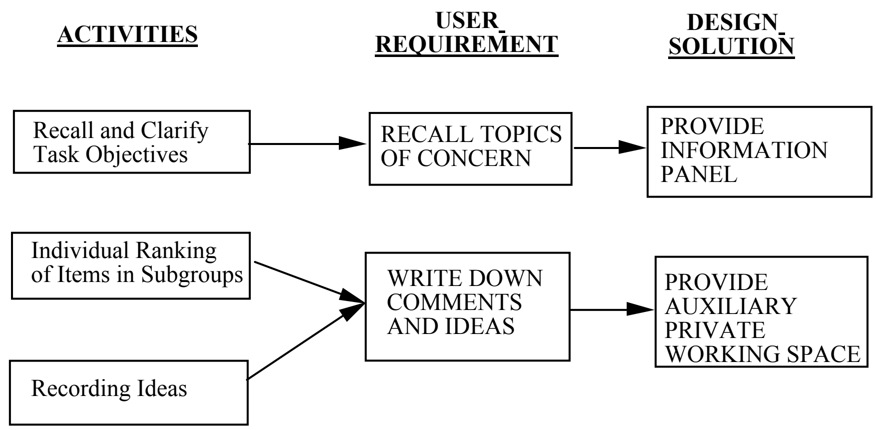


Factor 1: ***Screen Real Estate Managementt***

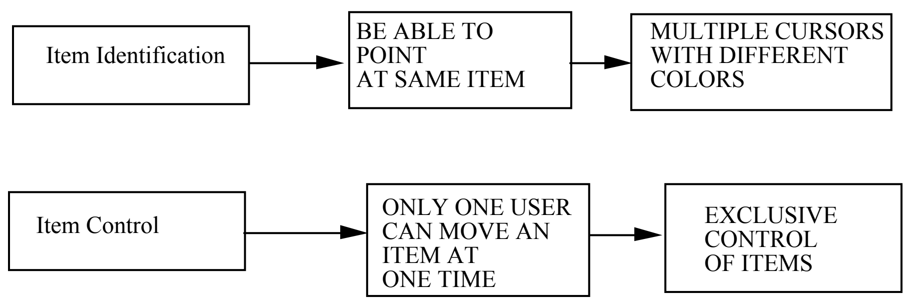


Factor 2: ***Matrix Mode***

Figure 2a. Mapping Activities to User Requirements and Design Solutions – (I)



Factor 3: ***Auxiliary Working Space***



Factor 4: ***Concurrency Control and Coordination***

Figure 2b. Mapping Activities to User Requirements and Design Solutions – (II)

Scope of the design process: The scope of the design process is constrained by the approach employed in this study. First, the way in which the task is framed and the materials provided to the subjects can bias the observations. For instance, if the participants had been provided the initial list on a single sheet of paper a very different design of the interface may have resulted. In this study, the assumption is made that it is advantageous to have a visual image of the relative ranks during the ranking process. The use of cards provides this visual image and naturally suggests a direct manipulation computer interface.

Second, the computer environment makes certain processes easy that are difficult without the computer. In instances where the computer processes are easier or more intuitive, it may be unwise to reproduce the manual process on the computer. In this study, it was assumed that an icon-based interface would be more appropriate than an interface that required users to write the numeric ranks beside the item. Knowing that screen estate will be limited in the software implementation, the space that was made available to place the cards was less than the total space required if all cards had to be visible. In this way, it was hoped to come up with results that would be relevant to the existing technology.

Third, the task of ranking twenty-five occupations is relatively simple and the results may not carry much significance to group members. Thus, there is little likelihood of major conflicts surfacing. The absence of major conflicts during the interactions precludes observations on how such conflicts are resolved. Hence, the conflict resolution process in the interface may be relatively simplistic.

Fourth, the process of arriving at the design solution from the user requirements is somewhat subjective. This is so in those instances when actions can be easily performed in the computer environment but not so easily in the non-computer environment. For example, scrolling of the window was permitted in the prototype to enable the users to see all items. The inclusion of scrolling in the design solution is not a result of the observations, but reflects the subjective belief of the researcher that scrolling is beneficial.

Description Of The Prototype

A prototype was built to allow one to four people to perform a ranking task interactively, while working at their own workstations. The current implementation assumes that the users will be able to communicate orally, if necessary. The actions of all users are immediately transmitted to the other workstations, so users are able to see and discuss each participant's ranking preferences as he/she performs the action.

The main window of the multi-user ranking program (see Fig. 3) is composed of two parts: the working area where the actual ranking task is done, and a control section that contains five icons to activate different activities.

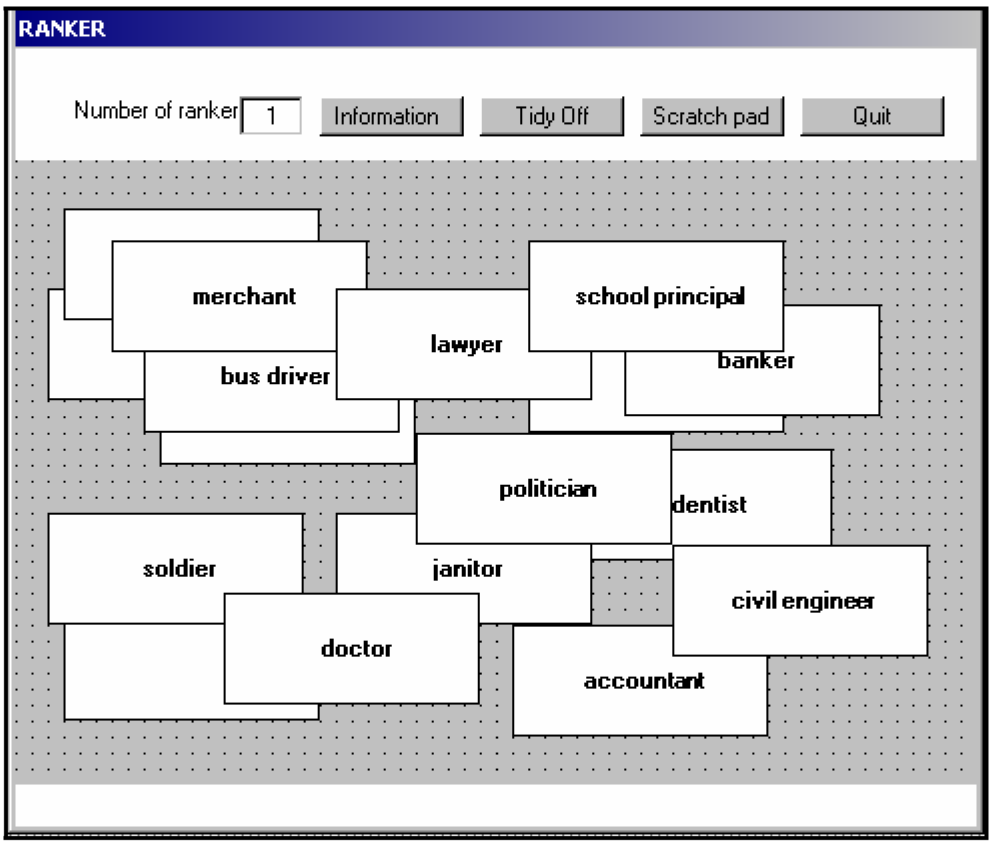


Figure 3. Main Window of Multi-User Ranking Program – Tidy OFF Mode

The working area covers about 90% of the space in the main window. Items to be ranked are represented as card-type icons in the working area (see Fig. 3). These items can be moved around in the working area by clicking on them and dragging them to the desired position. Only one user can move an item at a time and the control of it will be released when a user releases the mouse button.

A control section is placed on the top in the main window of the program, with one Edit-Box (a standard Windows control) and four buttons. The former is labeled "Num of rankers" and the latter are labeled "Information", "Tidy", "Scratch Pad", "Quit".

The "Num of ranker" edit box shows the number of participants in the ranking session. This information will be updated as participants logon to, or when they logout of the program.

The "Information" button calls up a panel, which displays information and/or ranking criteria that are specified in the beginning of the ranking session by the session initiator. The working area in the ranking program could be set to two different modes of display: the Tidy-ON mode and the Tidy-OFF mode. In the "Tidy-OFF" mode, the working area serves as a free working space in which users can move the items freely, or stack up the items to save space. In the "Tidy-ON" mode, a grid is imposed on the working area and all items will be aligned in the grid according to their relative position before the tidy mode is turned on (see Fig. 4). The "Scratch Pad" button activates the scratch pad, i.e., a private window, which provides a writing area for users to take notes during the ranking session. The "Quit" button allows the user to quit the ranking program.

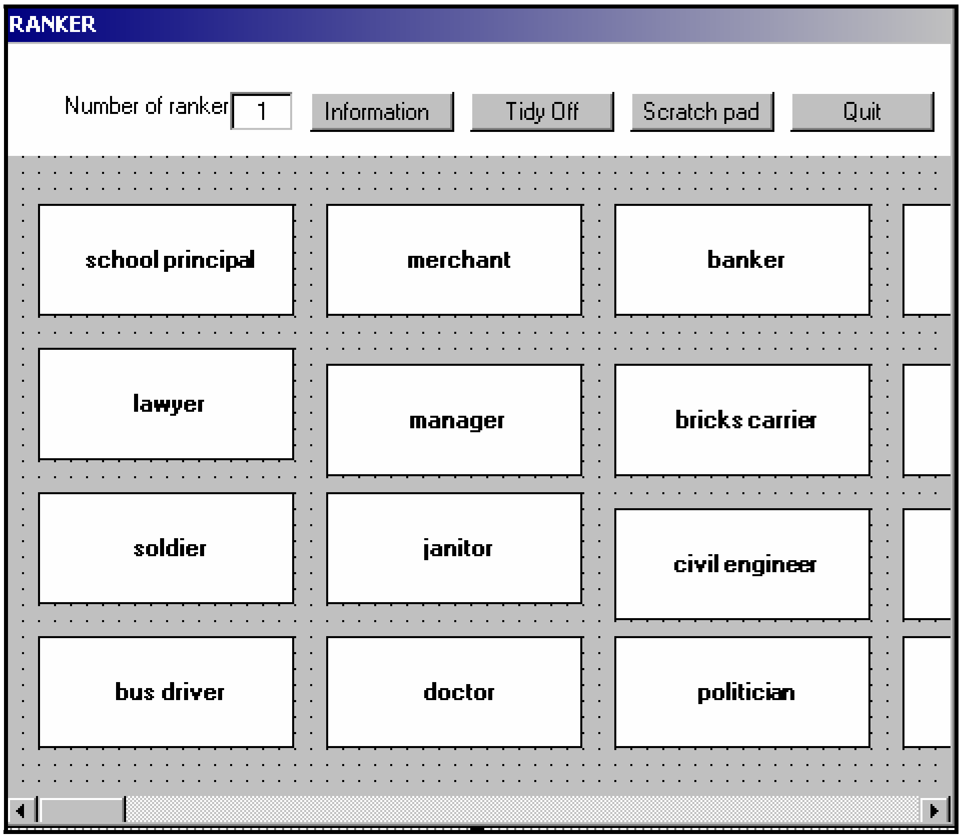


Figure 4. Main Window of Multi-User Ranking Program – Tidy ON Mode

USER FEEDBACK ON PROTOTYPE

The prototype, built based on the results of the analysis of observations of task performance in a non-computer environment, was informally evaluated by users. The term "informal evaluation" is used to reflect that no controlled experiment was performed, nor formal outputs measured. Instead, subjects used two different systems to perform a ranking task and provided verbal feedback. In this section, the user feedback is discussed.

User Testing Of Prototype

The user study was conducted with three 3-person teams. Each group used a ranking program with a single-user interface (SU-Ranker), i.e., the screens were not coupled, and the prototype implementation of the multi-user ranking program (MU-ranker) to perform a group ranking task.

In the SU-ranker, all items to be ranked are arranged in one column, and users can use the mouse to drag and move the item vertically along the SU-ranker. On the left of the items is a list of numbers showing the rank position of the items. Each participant ranks the items individually. When the ranking is completed, average ranks of the items for the group are displayed. The MU-ranker was the prototype implemented in this study. Users interacted dynamically to arrive at a consensus ranking.

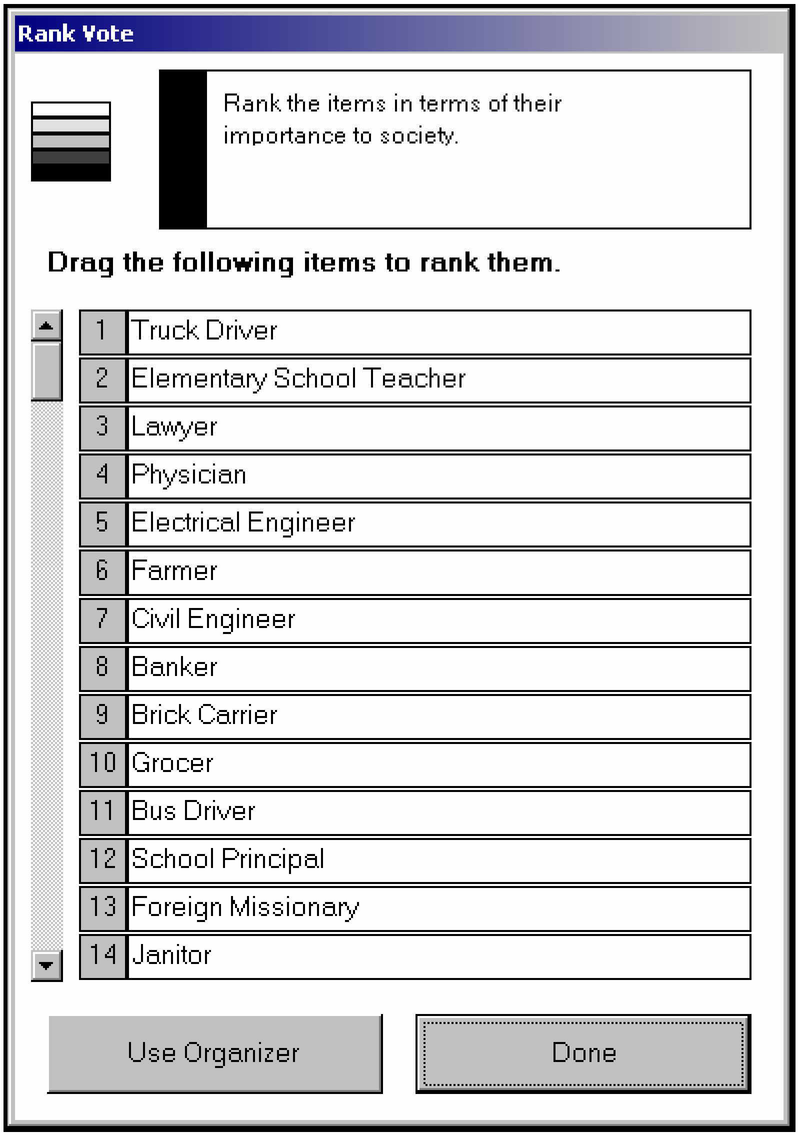


Figure 5. Single-User Ranker Implemented for *Meeting Place*

Lessons From User Testing

Observations: Issues in this category include the time to completion and the typical sequence of using the interface. In general, it took longer to complete the ranking task using the multi-user system (about 32 minutes on average) than when using the SU-ranker (about 18 minutes on average). In the SU-ranker, the system does not force subjects to come to a consensus, while in the multi-user ranker, the group has to reach consensus. Hence, more discussion and communication is required for the multi-user system. It is probable that if the group were required to arrive at a consensus with the SU-ranker, the time to completion would be comparable in the two cases.

The typical sequence of use for the MU-ranker was as follows: the group discussed the topic of ranking before beginning the ranking task. The group then decided on the arrangement of the ranked items, such as placing the most important item on the upper left hand corner and then going from the top to the bottom. During the ranking session, eight out of nine users referred to the ranking information panel and reviewed the topic of ranking. However, none of the users used the scratchpad to take notes.

For the SU-ranker, the groups started the ranking process by verbally clarifying the topic of ranking. Then, each participant worked on his/her own list of items without further discussion. When they completed the task, each participant sent their result back to the issue initiator.

User Feedback: The improvements suggested by the participants mostly concerned low-level issues. Most participants complained that sometimes they could not move an item, especially when the multi-user ranking program was in Tidy-ON mode. This could have been due to two reasons. First, user A may have tried to move an item without being aware that user B had control of it. Second, when the multi-user ranking program was in Tidy-ON mode, response time was relatively slow.

One participant suggested that the slots in the grid be numbered when Tidy mode is ON. She found that it was confusing to figure out how the items were arranged when Tidy mode is ON. Three users suggested that on-line help function should be added to the program to explain how the ranking program works. One participant suggested that the window of the multi-user ranking program should be enlarged so that she will be able to put all twenty-five items in the window without overlapping.

All suggestions from the users have a valid basis. The response of the system was known to be slow. The software will have to be re-implemented to address that issue. The suggestions to number the grids and include on-line help are useful feedback. The suggestion to enlarge the window is not useful as it merely postpones the problem of limited screen real estate.

Overall, some participants thought that the multi-user ranking program was too cumbersome. Participants said that they liked SU-ranker because they had total control of all items and the ultimate right to make the decision. However, when shown the aggregated rankings of the group, they disagreed with several of the ranks. Thus, one could say that in terms of process, the single-user interface may be preferred, but in terms of the outcome, the multi-user interface may be preferred.

Based on observing the users and the few requests for assistance during the use of the interface, there is support to indicate that the multi-user interface was adequately intuitive. User feedback has provided some useful information, but has failed to support the need for some of the features that were included on the basis of user-centered analysis. In particular, the usefulness of the dual mode has not been substantiated, nor has the need for a private space been observed. New features, such as numbering the slots and providing a help screen, were suggested. Further, issues related to intuitiveness may be secondary to issues related to control and coordination when individuals evaluate multi-user interfaces for group tasks. A less intuitive interface may cause problems for the user, but a more intuitive interface does not necessarily resolve user concerns about control and access.

LESSONS FROM THE STUDY

In the long run, we believe that the implementation of the prototype itself in this study is less significant than the lessons learnt from the experience of implementing the interface based on the observations of subjects. The following points are worthy of note. First, technology is both limiting and expanding. To consider the issue of technology being limiting, one of the observations was that participants in the non-computer environment used two or more fingers at the same time on some occasions to manipulate the cards. It is difficult to mimic this action in the computer environment with the current state of the art of the technology. Conversely, technology can be expanding, i.e., technology may enable some activities to be performed easily that are difficult to perform in the non-computer environment. For example, in the computer environment it is possible to scroll screens. This is a useful feature in that it allows the participants to spread items on an area larger than the screen size, and view partial sets of items at a time. In the non-computer environment, it is not possible to have scrolling screens. So, it is unlikely that any requirement deduced from the non-computer environment will lead to the design suggestion of a scrolling screen.

Second, some design features based on requirements identified by observing users in the non-computer environment were not used by the participants in the implemented system. For instance, it was observed that the 'private windows' provided for participants to keep reminder notes was not used by the groups working with the prototype. Similar observations have been reported by others (Dourish and Belloti, 1992). They speculate that 'this could be due to the pressure on group members to produce as much joint work as possible during the experiment' (p. 112).

The Dourish-Belloti speculation on the reason for the non-use of a feature leads to the third point. The adoption and use of new technology occurs over a period of time. DeSanctis and Poole (1994) have put forth the adaptive structuration theory to explain the complexity of adaptation of advanced technologies based on their experiences with group support systems. The gist of their arguments is that groups have existing structures; when new technology is made available, new structures that are a part of the technology becomes available. Groups adopt or reject some or all of the new structures based on a complex set of circumstances. The process of adoption or rejection may be immediate or may occur over an extended period of time. The fact that a feature is not used immediately does not necessarily mean that it is not useful.

Fourth, some requirements are not identified. In the initial design of the system, the rank of an item is indicated by its relative position in the arrangement of items on the screen. One of the subjects providing feedback on the prototype suggested that the locations be numbered to make it easier to keep track of the rank of an item. This requirement was not identified when we observed the participants performing the ranking task in the non-computer environment.

Fifth and last, the efficacy of the different starting points for user-centered design process has to be examined at every opportunity. Several processes have been used to determine the initial features to be included in a design, e.g., interviewing users and observing users performing tasks. The multiplicity of processes available raises the issue, what is the most cost-effective mode for the initial determination of user needs and user models in collaborative tasks? Our experience is that observing users in the non-computer environment and analyzing the observations can be very time consuming. In spite of the effort, some features identified were not used, and some useful features did not surface clearly. In the current study, as in other studies (e.g., Baecker et al, 1993; Olson and Olson, 1990), significant effort was expended in the observation / analysis step to arrive at the preliminary design. The challenge to designers is to evaluate the relative cost effectiveness of the processes that could lead to the preliminary design. In general, we concur with the prevailing belief that the design process should focus 'from the outset on the users, what they need to do and what they can do' (Olson and Olson 1991: 62). But this focus should not cause us to ignore the need to assess, rigorously and / or qualitatively, the methods used to arrive at the initial user needs and thus to make the overall process of user-centered design more cost-effective.

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